

Synthesis of New Thieno[3,4-*c*]thiophene Derivatives having Formyl Substituents

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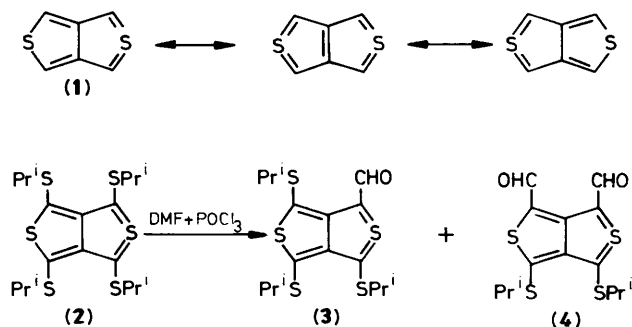
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The relatively stable new thieno[3,4-*c*]thiophene derivatives, 1-formyl-3,4,6-tris(isopropylthio)thieno[3,4-*c*]thiophene (**3**) and 1,6-diformyl-3,4-bis(isopropylthio)thieno[3,4-*c*]thiophene (**4**), have been prepared from 1,3,4,6-tetrakis(isopropylthio)thieno[3,4-*c*]thiophene (**2**) by substitution with the Vilsmeier reagent, and the structure of (**4**) has been determined by X-ray diffraction.

The thieno[3,4-*c*]thiophene system (**1**) has received much attention from synthetic¹ and theoretical² chemists, because of its nonclassical structure. However, little is known about the reactions of system (**1**)³ except for cycloadditions,¹ since hitherto the only isolable derivative has been the 1,3,4,6-tetraphenyl compound.^{1c} Previously, we reported the synthesis of 1,3,4,6-tetrakis(alkylthio)thieno[3,4-*c*]thiophenes by the dimerization of 2,3-bis(alkylthio)cyclopropanethiones.^{1d} We now report our recent findings that mono- and di-formyl substituted thieno[3,4-*c*]thiophenes may be prepared from 1,3,4,6-tetrakis(isopropylthio)thieno[3,4-*c*]thiophene (**2**) by reaction with Vilsmeier reagent. This reaction is the first example of a substitution reaction of the system (**1**).

The reaction was carried out as follows. Phosphorus trichloride (1.5 equiv.) was added dropwise to *N,N*-dimethylformamide (DMF) at 0°C with stirring under nitrogen. A solution of (**2**) in methylene chloride was added slowly. The mixture was stirred for 1 h at -5°C, poured into aqueous sodium hydrogen carbonate, and extracted with methylene chloride. The extract was dried, concentrated, and chromatographed on silica gel to give 1-formyl-3,4,6-tris(isopropylthio)- (**3**) and 1,6-diformyl-3,4-bis(isopropylthio)thieno[3,4-*c*]thiophene (**4**) as violet crystals in 33 and 14% yields, respectively. [(**3**), m.p. 75–77°C (decomp.); i.r.

(KBr) 2910, 1610, 1410, 1345, and 1160 cm⁻¹; ¹H n.m.r. (CDCl₃) δ 1.29 (d, 6H), 1.35 (d, 6H), 1.46 (d, 6H), 3.26 (sep., 1H), 3.37 (sep., 1H), 3.69 (sep., 1H), and 10.5 (s, 1H); u.v. (MeCN) λ_{max} 309 (log ε 4.14), 378 (3.62), and 580 nm (4.00). (**4**), m.p. 151–152°C; i.r. (KBr) 2920, 1580, 1515, 1435, 1355, 1240, 1200, 1130, 1110, 1085, and 1030 cm⁻¹; ¹H n.m.r. (CDCl₃) δ 1.59 (d, 12H), 3.70 (sep., 2H), and 10.2 (s, 2H); u.v. (MeCN) λ_{max} 307 (log ε 4.31), 375 (3.95), 395 (3.84), and



Scheme 1

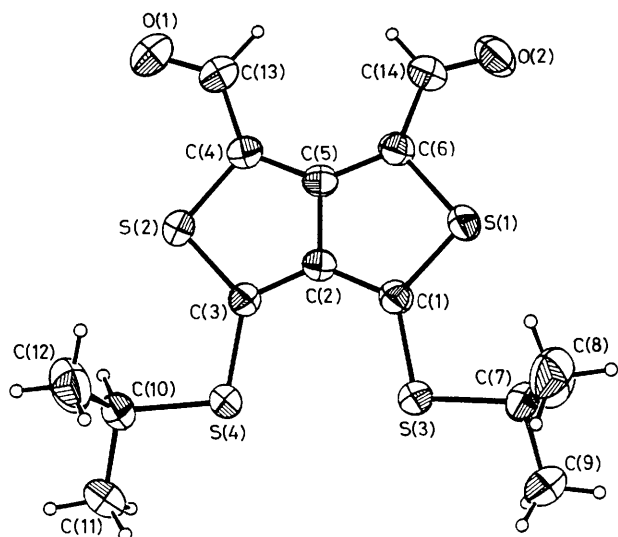


Figure 1. Molecular structure of (4). Selected bond lengths (Å) and angles (°): S(1)–C(1) 1.701(1), S(1)–C(6) 1.742(2), S(2)–C(3) 1.697(2), S(2)–C(4) 1.734(1), S(3)–C(1) 1.716(2), S(3)–C(7) 1.822(3), S(4)–C(3) 1.723(1), S(4)–C(10) 1.829(2), O(1)–C(13) 1.222(4), O(2)–C(14) 1.227(3), C(1)–C(2) 1.410(3), C(2)–C(3) 1.409(2), C(2)–C(5) 1.441(2), C(4)–C(5) 1.408(3), C(4)–C(13) 1.422(4), C(5)–C(6) 1.408(3), C(6)–C(14) 1.411(3); C(1)–S(1)–C(6) 94.4(1), C(3)–S(2)–C(4) 94.4(1), S(1)–C(1)–C(2) 110.3(1), C(1)–C(2)–C(5) 113.5(1), C(3)–C(2)–C(5) 113.4(2), S(2)–C(3)–C(2) 110.3(1), S(2)–C(4)–C(5) 110.3(1), C(2)–C(5)–C(4) 111.6(1), C(2)–C(5)–C(6) 111.8(2), S(1)–C(6)–C(5) 110.1(1). There are two crystallographically independent molecules (A or B) in the asymmetric unit. An ORTEP drawing of molecule A is shown; the conformations of two molecules are almost identical except for the isopropyl residues.

590 nm (4.15)]. When excess Vilsmeier reagent (5 equiv.) was used, (4) was formed exclusively in 51% yield.

The positions of the two formyl groups of (4) were determined by X-ray diffraction. Figure 1 shows the molecular

structure.† Compound (3) was stable in the air for several days and (4) for several weeks. The stability of 1,3,4,6-tetraphenylthieno[3,4-c]thiophene seems to result from steric effects. However, the remarkable stability of (4) must depend not on steric hindrance, but on the electromeric effect of the substituents. The formation of (4) indicates that the 6-position of (3) is more nucleophilic than the 3- and 4-positions.

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References

- (a) M. P. Cava and N. M. Pollack, *J. Am. Chem. Soc.*, 1967, **89**, 3639; (b) M. P. Cava, N. M. Pollack, and G. A. Dieterle, *ibid.*, 1973, **95**, 2558; (c) M. P. Cava and G. E. M. Husbands, *ibid.*, 1969, **91**, 3952; (d) S. Yoneda, K. Ozaki, T. Inoue, A. Sugimoto, K. Yanagi, and M. Minobe, *J. Am. Chem. Soc.*, 1985, **107**, 5801; (e) J. Nakayama, A. Ishii, Y. Kobayashi, and M. Hoshino, *J. Chem. Soc., Chem. Commun.*, 1988, 959.
- (a) M. J. S. Dewar and N. Trinajstić, *J. Am. Chem. Soc.*, 1970, **92**, 1453; (b) C. Müller, A. Schweig, M. P. Cava, and M. V. Lakshmikantham, *ibid.*, 1976, **98**, 7187; (c) R. Gleiter, R. Bartetzko, G. Brähler, and H. Bock, *J. Org. Chem.*, 1978, **43**, 3893; (d) K. J. Miller, K. F. Moschner, and K. T. Potts, *J. Am. Chem. Soc.*, 1983, **105**, 1705; (e) T. Kobayashi, K. Ozaki, and S. Yoneda, *ibid.*, 1988, **110**, 1793, and references cited in these papers.
- M. P. Cava, M. Behforouz, G. E. M. Husbands, and M. Srinivasan, *J. Am. Chem. Soc.*, 1973, **95**, 2561.

† Crystal data for (4): $C_{14}H_{16}O_2S_4$, $M = 344.54$, triclinic, space group $P\bar{1}$. $a = 11.670(2)$, $b = 15.493(2)$, $c = 11.594(2)$ Å, $\alpha = 115.52(1)$, $\beta = 116.68(1)$, $\gamma = 63.63(1)^\circ$, $U = 1606.5$ Å³, $Z = 4$, $D_c = 1.424$ g cm⁻³, $F(000) = 720$. Data were collected on an Enraf-Nonius CAD-4 diffractometer using Mo- K_α radiation. The structure was solved by direct methods and refined by full-matrix least-squares to a final R value of 0.027 for 4737 absorption-corrected independent reflections [$I > 3\sigma(I)$]. There are two crystallographically independent molecules in the asymmetric unit. Atomic co-ordinates, bond lengths and angles, and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre. See Notice to Authors, Issue No. 1.